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(54) **A display arrangement**

(57) A display arrangement is disclosed that comprises a liquid-crystal panel and an object to be viewed, wherein the object to be viewed is made visible to a viewer by making substantially transparent the panel and thereby allowing light travelling along a path that passes through the panel from the object to be viewed to reach the viewer. The arrangement may include two or more liquid crystal panels whose opacities are independently, and preferably continuously variable thus presenting the viewer with a temporal sequence of images. An arrangement which finds use in a gaming machine comprises a liquid-crystal panel 3a having discrete and independently controllable liquid-crystal regions 6, with an object to be viewed 2, which may be illuminated (light source not shown) by reflected or transmitted light.

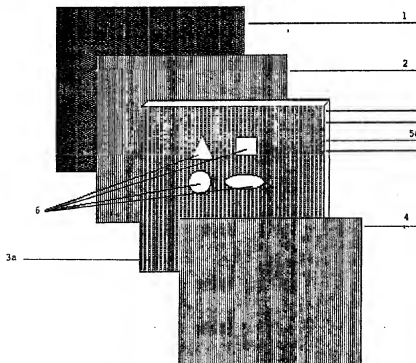


Figure 2. LCD Patent Application - Multiple Shutter

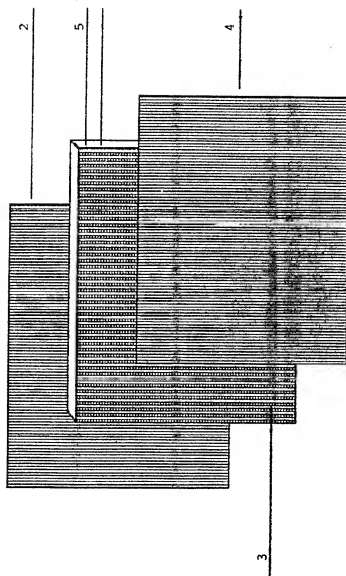


Figure 1a LCD Patent Application - Reflected Light

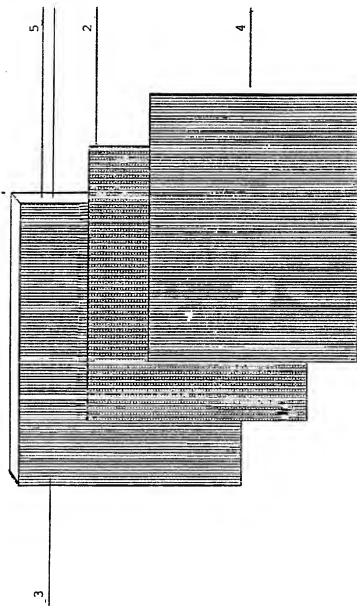


Figure 1b LCD Patent Application - Transmitted Light

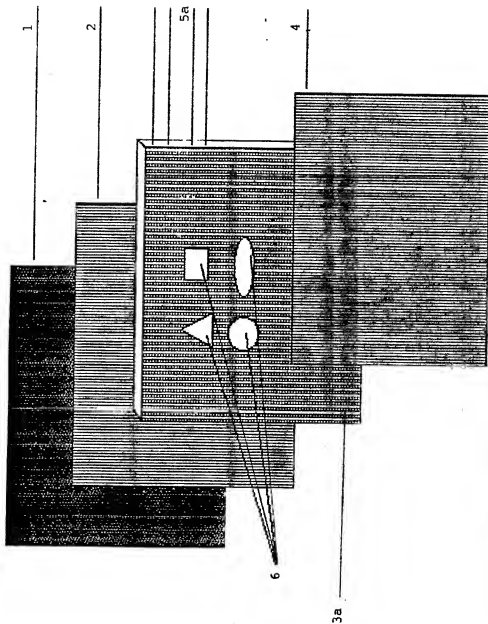


Figure 2. LCD Patent Application - Multiple Shutter

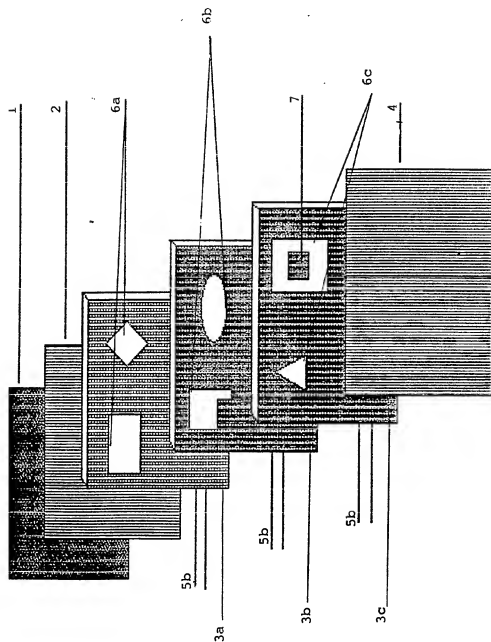


Figure 3. LCD Patent Application - Multiple Sheets

A DISPLAY ARRANGEMENT

This invention relates to a display arrangement which employs a liquid-crystal display panel and especially to one for use in the display of a gaming machine or an amusement machine. More particularly, the present invention relates to a display arrangement of the type in which the liquid-crystal display panel does not figure as the immediate means for image or symbol presentation, but rather as a means for controlling the visibility of objects, such as symbols or characters, separate from the liquid-crystal display panel.

Liquid-crystal displays are very widely used in industry; characteristic of them all is the action of the liquid-crystal panel as a modulator of a substantially uniform field of light. With a wrist-watch display, for example, natural ambient light, substantially uniform in intensity when incident upon the front surface of the liquid-crystal panel, is modulated in its intensity by a spatial variation of opacity created across the panel by electronic control, in its passing through the panel from front to rear; and it is this modulation - and remodulation that occurs when the first-modulated light passes back through the panel after reflection by a reflector behind the panel - that essentially forms the image. The image information can properly be regarded as residing in the spatial variation of opacity, created in whatever manner, across the area of the liquid-crystal panel.

According to one aspect of the present invention, there is provided a display arrangement comprising: a liquid-crystal panel having a region the opacity of which is variable; and an object to be viewed; wherein the object to be viewed is made visible to a viewer when said region of the liquid-crystal panel is

substantially transparent by light that travels along a path that passes through said region of the liquid-crystal panel to reach the viewer.

According to another aspect of the present invention, there is provided a gaming or amusement machine having a display arrangement comprising: a liquid-crystal panel having a region the opacity of which is variable; and an object to be viewed; wherein the object to be viewed is made visible to a viewer when said region of the liquid-crystal panel is substantially transparent by light that travels along a path that passes through said region of the liquid-crystal panel to reach the viewer.

In the display arrangement of the present invention, there may be provided two or more liquid-crystal panels, each having a region the opacity of which is independently variable. Each panel may have more than one region, independently variable in opacity. The regions may be coloured.

Moreover, the display arrangement may have a plurality of objects to be viewed and, as indicated above, a plurality of liquid-crystal panels rather than respective singletons, since, in numbers, these allow arbitrarily complex displays rather than only simple ones, even displays able to reveal pseudo-three-dimensional composite objects to be viewed.

In one preferred embodiment of the present invention, the object is behind the liquid-crystal display (in the sense that light travelling from the object to a viewer must pass through the liquid-crystal display) and observable by the viewer through the display.

In another preferred embodiment, the object is between the liquid-crystal display and the viewer and is illuminated from behind the liquid-crystal display by a light source.

A convenient arrangement of the components of the display arrangement is one of layers, wherein any light source for transillumination constitutes a rearmost layer, before which might be one or more layers of objects to be viewed, before which in turn, might be one or more layers of liquid-crystal panels, before which in its turn, might be another light source. In an arrangement such as this, and possibly in other arrangements of the components too, the objects to be viewed might be regions of a light-transmitting material such as glass, made to have various opacities and possibly various colours.

As is usual with gaming machines and amusement machines, it is preferable that the display arrangement is able visually to present the viewer with a temporal sequence of images, each composed of a revealed object to be viewed or a revealed combination of objects to be viewed.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made to the accompanying drawings, in which:

Figure 1a shows schematically a simple display arrangement in accordance with the invention whose illumination is by reflected light;

Figure 1b shows schematically another simple display arrangement in accordance with the invention provided with a rear light-source for transillumination;

Figure 2 shows schematically a more complicated display arrangement in accordance with the invention whose liquid-crystal panel embodies a plurality of discrete and independently controllable liquid-crystal regions; and

Figure 3 shows a still more complicated display arrangement including a plurality of liquid-crystal

panels each with a plurality of discrete, independently controllable regions.

In its simplest expressions, depicted schematically in Figures 1a and 1b, the display arrangement essentially includes: a plain liquid-crystal panel 3 having an input port 5, and an object to be viewed 2. Also essential to its operation are light and an observer (not shown). External to the invention, and not illustrated but also essential to its operation nevertheless, is an opacity control means (not shown); its output signals, which will represent the required temporal variation of the opacity of the plain liquid-crystal panel 3, is fed, during operation, to the panel 3 through its input port 5. The machine glass 4 is an inessential sheet of a transparent material such as glass; it is illustrated so that the orientation of the whole might be clear.

Whether illumination of the object 2 is by light transmitted or reflected by the object 2, the machine glass 4, when provided, is always at the front of the arrangement; so that it stands, of all the components, closest to the observer. The observer stands anywhere before the machine glass 4. The liquid-crystal panel 3 and the object to be viewed 2 are positioned, from the viewpoint of the observer, both behind the machine glass 4, and one behind the other. When illumination is by transmitted light, the liquid-crystal panel 3 comes typically behind the object 2 (Figure 1b), although these positions may be reversed. When by reflected light, the liquid-crystal panel 3 comes before the object 2.

When illumination of the object 2 is by reflected light and the basic arrangement is therefore as shown in Figure 1a, the required light source, be it incorporated as part of the display arrangement or not, will usually be in a position before the liquid-crystal

panel 3. It is of no fundamental importance to the invention whether the light source is between the liquid-crystal panel 3 and the machine glass 4, when it will likely be an arrangement of one or more electric
5 lamps; or before the machine glass 4, when it will likely be ambient light, natural or artificial. It is possible for light source to be situated between the object 2 and the liquid-crystal panel 3, or indeed in
10 any place within or without the display arrangement from which some of its generated light can fall on the object 2, then be reflected by the object 2, then pass through the liquid-crystal panel 3 such that the observer can detect it by sight.

When, alternatively, illumination of the object 2
15 is to be by transmitted light and the basic arrangement is therefore as shown in Figure 1b, the required light source, be it incorporated as part of the display arrangement or not, will usually be in a position behind the object 2, which object 2 will then be, at
20 least in part, of a light-transmitting nature, for instance, comprising glass or perspex or similar material. The light source might be an arrangement of one or more electric lamps provided with a diffuser, or it might be daylight to be transmitted to the object 2
25 to be viewed through a translucent diffuser, or any other suitable arrangement. Again, it is not altogether necessary for the light source to be in its usual position, that is behind the object 2; it may be in any place within or without the display arrangement
30 from which some of its generated light can pass to the object 2, then be transmitted by the object 2, then pass through the liquid-crystal panel 3 such that the observer can detect it by sight.

The display arrangement is operated in the
35 following manner, whether arranged for reflected-light illumination or transmitted-light illumination.

With the intensity of light from whatever light source is in use remaining substantially the same, or at least remaining above a minimum level so that the object 2 would be visible if the liquid-crystal panel 3 were of its lowest possible opacity, the opacity of the liquid-crystal panel 3 is varied by way of the opacity control means and the input port 5. This opacity variation, by its occurrence in the optical path travelled by light starting at the light source and reaching the observer by way of the object to be viewed 2, is performed to suit some display purpose; for instance, to make the object 2 visible and invisible at different times during a game of some description, for example, in order to present to the observer information pertaining to the state of the game at those times.

The opacity will often be varied between only two degrees: a high opacity to conceal entirely the object; and a lower opacity to render it as visible as possible given the negligible optical limitations of liquid-crystal panels in their most transparent state (associated with light absorption and scattering and other inconvenient optical phenomena). But control need not be restricted to this. The opacity might be continuously varied between these two limits, in some circumstances, to vary continuously the visibility of the object 2; perhaps to represent some continuously variable quantity in a game, such as time remaining or strength or speed, for example; or perhaps to achieve a fading in or a fading out of an image.

More complex than the embodiments of Figures 1a and 1b is the embodiment illustrated in Figure 2. It shares the essential features of the simpler embodiments: a liquid-crystal panel 3a, more complex though than that of the simplest embodiments; and an object to be viewed 2; and similarly essential are the

light source (unillustrated) and observer
(unillustrated), as well as a more complex opacity
control means which is external and unillustrated, and
a more complex input port 5a. It may also be fitted
5 with a machine glass 4, as above.

The physical arrangement of this embodiment's
components is also the same as the simpler
embodiments', and as with them illumination can be by
reflected or transmitted light, with light sources
10 arranged in the same ways as described above,
accordingly. It should be noted that Figure 2 only
illustrates an embodiment arranged for reflected-light
illumination.

It is the liquid-crystal panel 3a with its input
15 port 5a that distinguishes this embodiment from the
simplest embodiments above; formed in the panel is a
plurality of physically discrete liquid-crystal regions
6, each of which can be independently controlled or can
be a member of an independently controlled group,
20 rather than a single region as has the liquid-crystal
panel 3 of the embodiments described above. Each such
region's 6 opacity can be controlled in the same way as
the single region of the above described embodiments;
hence the input port 5a of the liquid-crystal panel 3a
25 includes an input channel for each independent region
and for each independent group of regions.

By this improvement, the variety of images,
symbols and characters that can be displayed by the
display arrangement is increased enormously. A few of
30 the new possibilities are described as examples.
Composite objects can be built up or taken down, as,
for example, a wall might be built or demolished as an
image, brick by brick. Also, some of the objects 2 can
be covered by a plurality of the liquid-crystal regions
35 6 of the liquid-crystal panel 3a and thus parts and
combinations of parts of them can be revealed and

obscured and shaded; it is possible by this to contrive, for example, a guessing game in which the players' objective is to guess the identity of a progressively revealed thing. A moving object could be
5 simulated by revealing copies of the object along a trajectory, one at a time, and one after another. And so on.

More complex than the embodiment illustrated in Figure 2 is the embodiment illustrated in Figure 3. It
10 is similar to the embodiments already described but is essentially distinguished from the embodiment illustrated in Figure 2 by its having a plurality of liquid-crystal panels 3a, 3b and 3c, which each have one or more discrete and independently controlled
15 liquid-crystal regions 6a, 6b and 6c, and groups of liquid-crystal regions, like the liquid-crystal panel of the embodiment of Figure 2. Typically, there may also be a plurality of objects or object layers at different distances along the line of sight of the
20 observer, though only one is illustrated in Figure 3.

The multiplicity of liquid-crystal panels and the possible multiplicity of objects complicates the physical arrangement. Typically, the physical position of the pair of components consisting of liquid-crystal
25 panel 3a and object 2 in Figure 2, will be taken instead by three such pairs, one behind the other, so that liquid-crystal panels alternate along the line of sight with objects or object layers.

A particular advantage of this embodiment is the
30 possibility of displaying pseudo-three-dimensional composite objects composed of parts of different object layers revealed by liquid-crystal regions from different liquid-crystal panels. Another illustrative advantage is the possibility of displaying the same
35 broad region of an object or object layer in different ways by control of liquid-crystal regions from

different liquid-crystal panels whose centres are positioned roughly collinearly and along a line parallel to the line of sight. In this way, for example, a picture might be framed in a variety of ways of which the observer's preference might be chosen after each has been tried, with one frame per liquid-crystal panel.

An advantage of all embodiments having a plurality of liquid crystal regions in the manner of the embodiments of Figures 2 and 3, is that a single light source only is needed for all illumination of possibly many parts of objects and combinations thereof. Presently, many gaming and amusement machines have one light source per object or object part. This is an economic disadvantage as well as one of complexity.

The repertoire of displays of the invention according to any embodiment may be increased by the possibility of using colour. Naturally the objects to be viewed can be coloured objects; but it is further possible to obtain liquid-crystals dyed in various colours. By their use, in any of the liquid-crystal panels of embodiments of the invention, colour can be added to monochromatic objects to be viewed; coloured objects to be viewed can have their apparent colours modified.

Although an embodiment has not been described in which objects are illuminated by reflected light, and other objects or the same ones or some of the same ones are illuminated by transmitted light at the same time, such embodiments are possible and are even more flexible than those described above by the addition of this extra degree of freedom.

All of the illustrations show embodiments of the invention in which the components are represented as parallel planes. It is not to be implied from this that the invention is restricted to such arrangements;

- nor that any of the components needs to be substantially planar; nor yet that any substantially planar components must be arranged substantially parallel with another. The only essential requirement
- 5 of the invention is that light is reflected or transmitted by an object to be viewed and reaches an observer via a liquid-crystal panel with which to influence the visibility or appearance of the object to the observer.

CLAIMS

1. A display arrangement comprising: a liquid-crystal panel having a region the opacity of which is variable; and an object to be viewed; wherein the
5 object to be viewed is made visible to a viewer when said region of the liquid-crystal panel is substantially transparent by light that travels along a path that passes through said region of the liquid-crystal panel to reach the viewer.
- 10 2. A display arrangement according to claim 1, wherein there are provided two or more liquid-crystal panels, each having a region the opacity of which is independently variable.
3. A display arrangement according to claim 1 or
15 2, wherein the or each panel includes more than one region, each of which regions is independently variable in opacity.
4. A display arrangement according to claim 3, wherein the regions are coloured.
- 20 5. A display arrangement according to any one of the preceding claims, in which there are a plurality of objects to be viewed and a plurality of liquid-crystal panels.
6. A display arrangement according to any
25 preceding claim, wherein the said object is behind the liquid-crystal panel (in the sense that light travelling from the object to a viewer must pass through the liquid-crystal display) and observable by a viewer through the display.
- 30 7. A display arrangement according to any one of claims 1 to 5, wherein the object is between the liquid-crystal display and the viewer and is illuminated from behind the liquid-crystal display by a light source.
- 35 8. A display arrangement according to any preceding claim, wherein the opacity of the or each

liquid crystal panel is continuously variable.

9. A gaming or amusement machine including a display arrangement in accordance with any one of the preceding claims.

- 5 10. A display arrangement substantially as hereinbefore described with reference to the drawings.